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XVII.—*The Sponge-fauna of Norway ; a Report on the Rev. A. M. Norman's Collection of Sponges from the Norwegian Coast.* By Professor W. J. SOLLAS, M.A., F.R.S.E., &c.

[Plates VI. & VII.]

[Continued from vol. v. p. 409.]

Order TETRACTINELLIDA, Marshall.

Group *GEODINA*, Carter (*continued*).

Genus *PACHYMATISMA*, Bwk.

Pachymatisma Johnstonia, Bwk.

Acyonium primum, Diosc. (?), Donati, Hist. Nat. de la mer Adriat. (1758).

Halichondria Johnstonia, Bwk. Trans. Micr. Soc. vol. i. p. 63, pl. vi. (1841); Hist. Brit. Sponges, Johnst. p. 198 (1842).

Pachymatisma Johnstonia, Bwk. Monogr. Brit. Spong. ii. pp. 3 & 51; O. Schmidt, Zweites Suppl. Spong. d. Adriat. Meeres, p. 12 (1866); Carter, Ann. & Mag. Nat. Hist. 1869, vol. iv. p. 11.

Caminus osculosus, Grube, Mitth. ii. St. Malo u. Roskoff, p. 132, pl. ii. fig. 3 (1873).

Bowerbank's faithful description of this sponge renders unnecessary any thing more than a supplement on some points of its histology.

1. *The Cortex*.—(i) The outermost layer of the cortex is an exceedingly thin, colourless, and transparent membrane, which rests on a layer of bacillar spicules, homologous with the layer of minute stellates in other Geodine sponges.

(ii) The bacillar layer is single, *i. e.* only one bacillus thick, the bacilli lying parallel to its surface, orientated in every direction, in close contact with each other. Since there is nothing intervening between the superficial membrane and the bacillar layer, it is clear that the former must be the ectoderm, if the generalization hold good that all the skeletal parts of the sponge originate in the mesoderm. That it now exhibits no ectodermic structure is in full accordance with Schulze's observations, who states that he has never yet seen the characteristic platten-cell outlines in spirit-specimens, but only in fresh specimens under silver or gold treatment.

(iii) The succeeding dermal layer is described by Bowerbank * as "a stratum of membranous structure and sarcode destitute of gemmules (globates)." It is of very variable thickness, in some places 0·0038 to 0·0075 inch across, in others absent, the underlying globates then coming in contact with the bacillar layer; it closely resembles the vesicular or vacuolated connective tissue of *Geodia Barretti* (see *antea*, vol. v. p. 251); in some parts it consists simply of separate colourless, transparent, more or less oval, or polygonal cells with remarkably thin walls and devoid of contents, except for a very small quantity of colourless sarcode, in which may usually be detected a nucleus with its nucleolus (Pl. VI. figs. 5 and 13); in other places, however, the tissue exhibits in addition an intermediate substance, which joins the adjacent cells together, and appears to result from the metamorphosis and fusion of their walls; the intermediate substance is usually colourless and structureless; but sometimes it assumes a dusky grey tint, owing to the presence of abundant minute granules; it also appears in some cases to become finely fibrillated (Pl. VI. fig. 5).

(iv) The globate layer, 0·03 inch thick, has the same structure as in other Geodine sponges. The ligaments which join adjacent globates together consist of fine structureless parallel fibrillæ, amongst which at intervals occur parallelly granular threads, sometimes containing a nucleus and nucleolus (Pl. VI. fig. 11). They are probably derived, like the connective-tissue fibres, from elongated fusiform cells with hyaline walls and granular axial threads, in which the hyaline walls have become completely fibrillated, while the axial thread remains unchanged.

* Phil. Trans. 1862.

(v) The subcortical layer is similar to that of *Geodia Barretti*.

2. *The Mark*.—This is chiefly composed of a granular connective tissue like that of other Geodine sponges, but partly also of vesicular connective tissue; in places groups of granular protoplasmic cells, containing a number of highly refractive globules resembling oil-drops, are met with. The ciliated chambers measure about 0·001 inch in diameter.

3. *The Canal-system*.—(i) *Incurrent canals*. Commencing with an examination of the surface of the sponge, we find that *pores* are not universally distributed over it, some parts being quite destitute of them; and in these places transverse sections of the crust prove the corresponding absence of chones. In the poriferous surface we can frequently distinguish a number of roundish or polygonal opaque white areas, separated by slightly more translucent interspaces; in these areas are set the pores, a group of six to ten pores in each, though sometimes only one or two are visible, or, it may be, even none. If the tissue bearing the pores be removed from the sponge and examined in glycerine under the microscope (Pl. VI. fig. 4), it will be found to consist of a layer of dermal vacuolated tissue, covered by the epidermal and bacillar layers; between adjacent groups of pores, and serving to define them from each other, a row of globate spicules replacing the dermal tissue is seen in addition. The dermal tissue forms a thick framework between the pores, but thins out towards their margins, leaving these to be constituted by the epidermal and bacillar layers alone. It is quite clear that these pores, although doubtless capable of opening and closing by iris-like movements of the clear marginal membrane, are not vague and transitory, as has been asserted, but, on the contrary, persistent and well defined. In my specimens they are usually elliptical in form. With regard to their size, concerning which much confusion exists in published writings, I find that the diameter averages about 0·075 inch; sometimes it becomes as much as 0·12 inch, or as little as 0·002 inch. The majority are clearly visible to the naked eye. On examining the surface from which the poriferous layer has been removed, it will be found that a chonal cavity lies beneath each cluster of pores; the opaque white areas in which they are set are thus in fact chonal roofs, the opacity and whiteness being due to the absence of the globate layer beneath them.

The chones, of which we have next to speak, are closely similar to those of *Geodia Barretti*; they were first described

by Bowerbank *, and afterwards more fully by Carter †. My own observations, made on thin slices mounted some in glycerine and some in balsam, all showing the structure in the clearest possible manner, are different from those of Carter in several particulars, and accord with those made by me on *Geodia Barrettii*. A transverse section of the rind, giving a longitudinal section of the chones, is represented in fig. 3, Pl. VI. The chonal roof consists of the epidermis and bacillar layer above, bearing the pores; beneath follows the vacuolated tissue, with interspersed fibrous elements concentrically surrounding the pore-canals, which descend one from each pore. The pores in the centre of the roof lead directly into the chone, those at its sides into lateral canals, which may be regarded as an extension laterally of the main chonal cavity above the globate layer and beneath or through the dermis. They are best exposed in tangential sections of the chones. There is no trace of small independent canals traversing the crust outside the chones. The ectochone has the form of a truncated cone, the base being directed outwards; it is provided below with a well-developed sphinctral muscle, the origin of which is about on a level with the inner face of the globate layer; the endochone has almost or entirely disappeared, and the subcortical crypt is of very variable size and irregular form.

The epidermis and its associated bacillar layer are continued from the pores inwards, lining the poral canals and the whole cavity of the chone; they extend through the aperture of the sphincter (the bacilli becoming very rare here), and cover the walls of the subcortical crypt. Beneath the bacillar layer in the walls of the ectochone is a layer of dermal vacuolated tissue, about 0·002 inch thick; it lies immediately on the globate layer.

The chonal sphincter varies in thickness according to its degree of contraction; when fully closed, its lower side has a mamillary form and projects into the cavity of the subcortical crypt; this swollen protuberance may have given rise to the notion of a spiral tube descending from the sphincter, which does not really exist. It is covered by small roundish cells, which are most clearly seen at its central margin, and which are, without doubt, ectodermal. It consists chiefly of dark granular muscle-fibres, which stain deeply with carmine; they have a concentric and radiate arrangement, but are mostly concentric.

(ii) *The Excurrent Canals.* The same differences as dis-

* Brit. Spong. vol. i. p. 101.

† Ann. & Mag. Nat. Hist. 1869, vol. iv. p. 13.

tinguish the excurrent and incurrent canals in *Isops* are to be met with here.

The ultimate excurrent canaliculi flowing from the flagellated chambers join together into larger canals; and these, after one or more confluences, empty themselves into one or other of the main excurrent trunks, which, maintaining a tolerably uniform diameter for a considerable part of their course, at length open freely into a large, more or less spherical chamber (Pl. VI. fig. 1, C, fig. 2, *b*); this chamber communicates, through an aperture guarded by a thick muscular sphincter, with a smooth-walled cylindrical tube (fig. 1, T, fig. 2, *a*), the external opening of which is somewhat reduced by an extension inwards of its surrounding margin. The walls of this tube, as well as its outer rim, consist of vacuolated tissue, covered by the epidermis, dermis, and bacillar layer; the vacuolated tissue extends down to the subcortical layer, which here consists of gelatinous connective tissue of the usual composition (fig. 1, *c*), bacilli, and long, delicate, thread-like fibres, a little swollen, granular, and nucleated in the middle, and directed lengthwise towards the sphincter; the free face of the subcortical layer, which here forms the wall of the spherical chamber, is covered by a dense layer of dark grey granular fibres (fig. 1, *f*).

The vacuolated tissue of the outer tube exhibits as it approaches the sphincter an increasingly large admixture of fibres, which appear partly to arise between its cells, partly to be introduced from the globate layer.

The sphincter is formed by the union of the subcortical tissue with that of the wall of the outer tube. When these two meet they assume a common direction, so as to extend across the axis of the tube; the tissue of the outer tube forms the upper part of the sphincter, and is traceable as a distinct component almost close up to its centre; it gives us the distinct small epidermal cells covering the upper surface, the bacilli beneath, and lower still the vacuolated cells intermixed with granular fibres. The subcortical layer forms the lower two thirds of the sphincter; it furnishes the layer of epithelial cells covering the lower face of the muscle; its outer dark granular fibrous layer sweeps into the lower part of the sphincter, increasing in thickness as it goes; while its gelatinous connective tissue constitutes the middle layer of the sphincter, extending into it as an intrusive wedge-like mass. Near the centre of the sphincter all these various constituents, except the epidermal and epithelial layers, are represented by dark-grey granular muscle-fibres alone, which, taking a concentric, radiating, and vertical direction, form a

central bobbin-shaped mass, easily distinguished from the other constituents by its dusky tint and the deep stain it takes with carmine. One must not omit to mention that amongst the muscle-fibres abundant bacilli occur thickly dispersed. These little spicules indeed pervade the whole of the sphincter, as much in one part as another: but it contains no stellates; these first appear in the underlying spherical chamber, the walls of which are lined by stellates and bacilli together.

The Skeleton.—The *bacilli* are clearly homologous with the minute dermal stellates of *Geodia*, their distribution in the sponge being precisely similar; in both sponges these dermal microliths pass through the cortex and enter the mark, into which, however, they extend only a little way, soon disappearing as we trace them towards the centre of the sponge, their place being taken by the larger stellates proper to the mark.

This homology is a point of some interest, since, taking into account the close family relations of *Geodia* and *Pachymatisma*, it clearly indicates for the bacilli and stellates a common origin; and the question arises as to which of the two is the more primitive form. Examining first their ontogeny, we find it possible to trace the bacillus from the adult form, cylindrical with rounded ends and roughened surface (like a comfit), to a smooth fusiform spicule with a central globular enlargement and pointed ends (fig. 10 *b*), which we may regard as a biradiate stellate.

From this we pass to a form in which the central enlargement has disappeared, and then finally to a fine hair-like rod (fig. 10 *a*), remarkably similar to one of the trichites of which the trichite-sheaves of *Stelletta Normani* are composed.

Turning next to the minute stellate of *G. Barretti*, we are able to trace it backwards, its thick rays becoming of hair-like fineness, and the whole progressively smaller, until it can be no longer followed under a Zeiss-H immersion lens; and yet it remains a multiradiate stellate to the end. Thus, from ontogeny we seem here to get no help at all. The two forms differ greatly in respect of variability, the minute stellates showing but little constancy in the number of their rays, some possessing twice as many as others; while the bacilli, on the other hand, are remarkably stable, seldom varying at all; now and then they sprout off a third ray (fig. 10, *d, e*), but so rarely that one has to look long for an instance. Since when once the stability of a form is disturbed it often continues to present variations, we might hence regard the bacilli as the original undisturbed forms, and the stellates as the variable descendants of a bacillus-sport.

The *stellates* of the mark possess a comparatively small number of rays, a character in curious consistency with the substitution of biradiate bacilli for multiradiate dermal stellates in this genus; six or eight rays is a common number; as many as twelve may occur; but reduction to four, three, or even two, is frequent. With only two rays in the same straight line, the spicule presents a central globular enlargement and looks like a magnified copy of a young bacillus.

A study of the various forms of these stellates is a study of nearly all the characteristic forms of spicules which distinguish the various groups of sponges: hexactinellid, tetractinellid, triradiate are all here, and a great number of other forms besides. We seem in these spicules to have the results of unhindered variation, freed from the conditions imposed by a selective environment.

The *long-shafted spicules* in the specimen under examination exhibit a great variety of monstrous growths: in many a number of siliceous globules cover as excrescences one end of the spicule (fig. 9); in others one end becomes bifid, trifid, or even quadrifid (fig. 6), the last deviation being met with in the usually simple proximal end of the shaft of a tetractinellid form; some, again, possess simple ends, but a double body (fig. 7); and, finally, in one instance the end of a spicule has sprouted out rays which are arranged in a combination of prong and anchor endings in one (fig. 8). Since anchors do not occur normally in *Pachymatisma*, this variation is of particular interest. Bowerbank has already remarked, in his description of the species, on the great variety of these spicules, and particularly says that their radii are frequently bifurcated or contorted to a great extent. This, and the irregular disposition of the trifid spicules, is worthy of notice in connexion with the possibility of a transition from the trifid to the quadriradiate Tetractinellids and the Lithistids.

Many of the spicules appear to be subject to some disease, by which the central canal has been enlarged till it occupies one third of the entire diameter, the axial thread remaining as a straight sharply defined rod of the usual size; sometimes it projects quite freely at the end of the spicule.

By manipulating the cover-glass over a teased fragment of the sponge the axial thread could be "wriggled" out nearly entire from the spicule. It is faintly bluish, transparent, structureless, very flexible, like a piece of sewing-thread, and takes a decided stain with magenta.

Some of the spicules are united where they touch in crossing each other by some tough brown-coloured matter, which stains with magenta and looks like spongin.

The *globates* agree in their general character and mode of development with those of other *Geodina*; and I have now only to allude to the statement that in their young form they closely resemble stellate spicules. This I cannot substantiate; closely as I have searched for transitional forms between *globates* and *stellates*, I have never yet been able to find any, any more than between *stellates* and *bacilli*. In thin slices mounted in balsam I have been able to trace the *globates* down to a young form, measuring something under $\frac{1}{1200}$ inch in diameter; but even in this earliest stage it consists of a vast number of minute trichites united into a central globule at their inner ends. Its outline is spherical, owing to the trichites ending at the same distance from the centre; and it is enclosed in a granular cell with a large young nucleus on one side, which takes a deep tint with carmine. It thus differs from a young stellate in just the same way as the stellate from a bacillus, *i. e.* by a great difference in the number of its rays. As the *globate* increases in size, each trichite becomes longer, thicker, and roughened over its free end, so as to resemble closely an adult bacillus. The *globate*, indeed, might now be well compared to a collection of bacilli, radiately grouped and fused together at their inner ends.

Classification.—The generic distinction of *Pachymatisma* is well founded, and is further supported by the character of its oscular openings.

In *Geodia Barretti*, which we regard as an illustrative species of the genus *Geodia*, we likewise have an oscular tube; but it differs in a most important manner from that of *Pachymatisma*; for while the latter is separated by a sphincter at its base from a common chamber below, in which the excurrent canals open freely by unconstricted apertures, the former, on the other hand, is without the common chamber and the common sphincter, and the excurrent tubes are severally and separately sphinctrated as they open directly into the oscular tube itself. In *Geodia* the oscular tube appears to result from the union of a number of excurrent chones, like those of *Isops*; in *Pachymatisma* it is produced by the over-development of a single one. In *Cydonium* there are no oscular tubes, and both excurrent and incurrent chones (if the distinction can here be maintained) are covered with a cribriform or poriferous roof, the very reverse of what holds in *Isops*, where neither excurrent nor incurrent chones are so provided. Translating the foregoing distinctions into a different nomenclature, it would seem that in *Isops* we have a compound stock consisting of a number of separate individuals, somewhat resembling an *Astræa*-stock amongst corals; in *Geodia* groups of these

individuals have become united into individuals of a higher order; in *Pachymatisma* single individuals have become more complicated by a branching or budding off of main excurrent canals, which are here to be regarded each as an individual of a lower order; in *Cydonium* we appear to have a case of lipostomism, the functions of an osculum being vicariously carried on by the poriferous chones.

Indicating the individual expressed by a single excurrent chone by the symbol 1, and that expressed by a single main excurrent canal by I, we may briefly formulate the relations of the four genera in the following diagram:—

<i>Isops</i>	1 . 1 . 1 . 1 . 1 . 1 . 1 .
<i>Geodia</i>	(1 1 1) (1 1 1 1)
<i>Pachymatisma</i>	0 . 0 . 1 . 0 . 0 . 0 . 1
	$\underbrace{\hspace{10em}}_{\text{I . I . I . I . I . I}} \quad \underbrace{\hspace{10em}}_{\text{I . I . I . I . I . I}}$
<i>Cydonium</i> ?	No obvious individuality beyond that of the entire stock.

Distribution. Kors Fiord, Norway, Station 23: 180 fathoms.

Bowerbank cites this sponge from Torquay, south coast of Ireland, Orkneys, and Wick, Scotland. We now have it from Norway; and Grube describes it, as pointed out to me by Mr. Norman, under the name of *Caminus osculosus* from St. Malo. It thus extends from Norway and the Orkneys on the north, to St. Malo on the south, and as far west as the Guliot caves on the south coast of Ireland; bathymetrically, it ranges from low-tide level to 180 fathoms.

Group *TETILLINA* (*TETHYINA*), Carter. (Pl. VII.)

Genus *TETILLA*, O. S.

Tetilla cranium, Müll.

1789. *Aleyonium cranium*, Müll. Zool. Dan. t. 85. f. 1.
 1815. *Tethya cranium*, Lmk. Mém. d. Mus. i. p. 71.
 1816. *Aleyonium cranium*, Lmx. Hist. d. Polypes, p. 347.
 1818. *Spongia pilosa*, Mont. Mem. Wern. Soc. vol. ii. p. 119, pl. xiii. figs. 1-3.
 1828. *Tethya cranium*, Flem. Brit. Animals, p. 519.
 1834. *Tethya cranium*, Blainv. Mém. d'Act. p. 544.
 1842. *Tetheu cranium*, Johnst. Brit. Spong. p. 83, pl. i. figs. 1-8.
 1864. *Tethea cranium*, Bwk. Monog. Brit. Sp. i. p. 182, pl. xxxi. fig. 362.
 1866. *Tethea cranium*, Bwk. Monog. Brit. Sp. ii. p. 83.
 1866. *Tethya cranium*, O. S. Adriat. Spong. ii. Suppl. pl. i. fig. 14.
 1867. *Tethya cranium*, Gray, P. Z. S. p. 543.
 1870. *Tetilla cranium*, O. S. Spong. Atl. p. 66.
 1871. *Tethya cranium*, Carter, Ann. & Mag. Nat. Hist. vol. viii. p. 104.

1872. *Tethya cranium*, Carter, Ann. & Mag. Nat. Hist. vol. ix. p. 419, pl. xxii. fig. 9.
 1874. *Tethya cranium*, Bwk. Monog. Br. Sp. iii. p. 315, pls. xiv. & lxxxix.

This interesting sponge, the occurrence of which in the Norwegian seas had been early noticed by Bishop Pontoppidan (Lamx. *loc. cit.*), is well represented in Mr. Norman's collection by several small but perfectly preserved specimens. A clear insight into its exquisite structure is afforded by a series of thin slices obtained by means of the freezing microtome, and mounted in balsam or glycerine. My chief regret is that its beauties have not found a more skilful pencil to portray them.

The sponge is approximately spherical in form, white, and with a hairy appearance due to the projection of the ends of the spicular fibres beyond its general surface. An oscule is clearly present, though Bowerbank and other observers have failed to find it. On this point Bowerbank is most explicit; his specimens were some two hundred in number, and, after careful searching, he could discover no trace of an oscule, pores, or intermarginal cavities, all of which in Mr. Norman's specimens can be easily demonstrated. Carter, it should be added, has called attention to the presence of a group of oscules in a specimen which came under his observation (Ann. & Mag. Nat. Hist. ser. 4, 1872, vol. ix. p. 419).

The oscule is a nearly circular opening, usually small (from 0·03 to 0·07 inch diameter), obliquely terminating a tunnel-like tube (fig. 6, *o*, transv. sec.) which runs for a short distance along the surface of the sponge; the tunnel-like roof of the tube is a thin imperforate membrane formed by the extension of the dermis; the floor is the ordinary dermis of the general surface, which retains its pores, and by their over-development assumes the character of a fenestrated membrane or network with round meshes.

The skin or dermal membrane rises tent-like about the ends of the projecting spicular fibres, and extends continuously from one to another, so as to completely invest the sponge. It is best seen by cutting off the ends of the projecting spicules, and viewing under an inch lens by reflected light (figs. 15, 16). One can then observe shining through the surface of the skin a number of thread-like fibres, which radiate outwards and downwards from the circumference of each spicular fibre as a centre, branching as they go, and anastomosing with those of adjacent centres to form a polygonal network, by which the overlying dermal membrane is mapped out, as it were, into a number of polygonal areas.

It is in these areas, which may be even and plain, or subdivided by smaller fibrous threads into a number of round or oval spaces, that the pores are situated: they are very small, from 0.001 to 0.002 inch in diameter; and the poriferous membrane is so tender and delicate that it would probably be torn away by an observer unsuspecting of its presence, and in this way may have escaped the notice of Bowerbank; when removed, the projecting spicular fibres appear below, each rising out of a fleshy papilla, the lower half of what we shall term a spicular column of the cortex. A good representation of the surface of the sponge, as thus denuded of its dermal membrane, is given by Johnston (*loc. cit.* pl. i. fig. 3). The spaces between the papillæ (Pl. VII. fig. 6), roofed over by the dermal membrane in the uninjured sponge, correspond to the intermarginal or subdermal cavities of other sponges.

Bisecting the sponge through its oscule, we distinguish on the cut face an external whitish rind and a pale greyish mark sharply defined from it; the skin and subdermal cavities are readily observable, forming the outer half of the rind; its inner half is a continuous whitish layer. In the mark, numerous canals are seen cut across; and one large one approaching close to the oscule, along a spiral course conformable to that of the spicular fibres, is clearly one of the main excurrent canals.

We now proceed to give a more detailed account of the structure of the sponge, as revealed in thin slices examined under the microscope.

The Ectoderm.—The study of this layer is full of perplexing difficulties, owing partly, no doubt, to the fact that one is limited to particular methods in investigating it, but partly also to the want of constancy in those characters which it clearly displays. It is in the subdermal cavities that its structure is most satisfactorily seen. There, on the sides of the spicular columns (Pl. VII. fig. 13) one may sometimes discover it as a superficial layer of irregularly polygonal plate-like cells, $\frac{1}{1500}$ to $\frac{1}{2500}$ inch in diameter, with small circular nuclei of a faint bluish tint, $\frac{1}{7500}$ to $\frac{1}{10000}$ inch in diameter, which sometimes project outwards beyond the plane of the membrane. This structure, by the loss of the polygonal outlines of its cells, readily passes into a thin membrane with scattered nuclei, of just the same size and appearance as those in the well-defined cells. If this were the only change, no difficulty concerning the ectoderm of the subdermal cavities need be felt; but in some places the minute C- and S-shaped spicules of the mesoderm are plainly imbedded

in the nucleated membrane, each spicule surrounding a nucleus, which does not differ in any apparent respect from those of the plate-like polygonal cells. There can be no question that these minute spicules and their nuclei are associated parts of the same cell; but how comes this cell into the ectoderm if all spicular structures are a product of the mesoderm? Can a mesoderm-cell have wandered into the ectoderm? and if one kind of mesoderm-cell why not others? and then what becomes of the sharp distinction between these two layers? The simplest explanation would, of course, be that of mistaken observation; but, after repeated examination of my preparations, I can see no reason for admitting this. But this is not all; for in many places a thin annular wall appears about the small round nuclei (Pl. VII. fig. 9), whence results a flat oval cell about $\frac{1}{2000}$ inch in diameter, devoid of contents except for a little clear colourless protoplasm, which may form a little slightly granular heap about the nucleus and extend from it to the outer wall; the appearance of the lining membrane is now that of a thin structureless film imbedding flat oval cells, at intervals varying from that of their own diameter up to close contact. No other structure can be seen more superficial than this, either when viewed face on or in transverse section, and consequently, one can scarcely help regarding it as the ectoderm; it is at least conceivable, though not probable, that it results from a change in the form of the plate-like cells, consequent on immersion in spirits; if these, on shrinking, assume an oval form and become connected by an exudation from the mesoderm which subsequently hardens, an appearance similar to that described might be produced.

The skin (Pl. VII. fig. 7), as the outer covering membrane may be briefly called, exhibits another change of structure. This consists in the appearance of an immeasurably thin structureless membrane, which is in many places thrown into numerous minute wrinkles having no apparent arrangement, except when traced to the margins of the pores, to which they are radiate. It rises tent-like about the projecting spicules individually. Associated with it, but lying on its under surface, as can be clearly perceived by examining it in optical section where it rises into tent-like projections or is most wrinkled, are the circular pale bluish nuclei of the subdermal epithelium, often so regularly disposed at nearly equal distances from each other, that one feels almost bound to regard the nuclei and membrane together as an ectoderm from which the polygonal outlines of cells have disappeared—until one finds round some of these nuclei, and lying on the underside of the membrane,

the same kind of oval annular wall before described. Hamate spicules are also found lying beneath the outer membrane. The interpretation of these observations is most difficult. If the outermost membrane be the ectoderm, why do not at least nuclei appear in it? since they are plainly seen in the subdermal ectoderm, and these have the same appearance as the nuclei which here occur below the outer membrane. If it is not ectoderm, but a structureless cuticula, where is the ectoderm? for it appears very improbable that a heterogeneous layer of oval cells, spicule-cells, and bare nuclei can represent this layer; by no means impossible, however, since, in spite of the beautiful demonstrations we have had from the masterly hand of F. E. Schulze, I do not yet feel quite convinced of the uniformity of this structure over all parts of the sponge, or that it presents the same constancy as in the other Metazoa. But it is reckless to speculate in the absence of any of the evidence possible, and the silver treatment may eventually, as I almost expect, bring out of the apparently structureless cuticula the polygonal outlines of epithelial cells; but, till that welcome sight appears, one must be content to take the facts as one finds them; and so provisionally the outermost layer is for me a cuticula, and the mixed cellular layer beneath a heterogeneous ectoderm. The cuticula and ectoderm together cover the exterior of the sponge, except in some cases near the small oval pore-areas (Pl. VII. fig. 15), which are situated in the meshes of the polygonal dermal network; in these it often happens that the cuticula is absent, or has thinned away beyond one's power of observation; for, although present on the surrounding skin, it is not possible to see what becomes of it as it is traced into the pore-area. The membrane in which the pores in these instances are set appears, when looked down upon from above, to consist of a structureless film which does not stain with carmine, and in which are imbedded granules, naked nuclei, similar nuclei surrounded by hamate spicules which often project out of the membrane, and flat oval-walled cells with similar nuclei; thus it has the same appearance as the ectoderm of the subdermal cavities. In addition, fine delicate filaments may be seen, which frequently run parallel in groups, crossing one another in the space between two pores, and then diverging so as to touch tangentially the edge of the pores. In the dermal network which forms the floor of the oscular tube and the roof of the subdermal cavity below, we can perceive a similar structure (Pl. VII. fig. 8); but transverse sections show here a superficial ectodermal layer with a thin mesodermic layer between, where the network is thickest; in the very thin layer which

lies between two pores the ectodermal layers come nearly into contact, though a few fine fibrils still seem to separate them; they clearly show, however, imbedded in their midst, and not lying below them, the characteristic round nuclei with hamate spicules surrounding them. These thin and narrow trabeculæ seldom contain oval cells; they are not wide enough; but these, along with granular cells, occur in the larger nodal areas where three or more trabeculæ meet (Pl. VII. figs. 9 & 10).

The edges of the pores are sometimes bordered by minute granular fusiform cells with a minute spherical nucleolus in an oval nucleus.

Between the upper and lower ectodermal layers of the skin is a layer of mesoderm of somewhat variable character, but mainly consisting of a clear colourless jelly-like matrix, in which are imbedded various cellular elements (Pl. VII. fig. 2). The most widely diffused, perhaps, are little circular or oval rings $\frac{1}{3000}$ inch in diameter, highly refractive, and of a pale bluish tinge, enclosing round nuclei $\frac{1}{10000}$ inch in diameter, of similar optical characters; these, scattered irregularly through the clear ground-mass, give it a curious appearance like spotted muslin. Immediately beneath the annular cells of the ectoderm succeed a number of separate, irregularly rounded, granular greyish-coloured cells with round nuclei; they might very well be an early form of the annular cells. Sometimes they form a layer two or three cells deep, sometimes thin out altogether. The remaining cellular constituents are fusiform granular cells, variously distributed; lying parallel side by side, they form the fibrous strands, which run just below the epidermis to map out the pore-areas from each other; sometimes they form a thin layer beneath the surface, in which they wander in all directions, and occasionally extend singly at right angles to the surface from the upper to the lower ectodermic layer. Approaching the spicular columns the dermal mesodermic layer thickens out, so that the upper and lower ectodermic layers become gradually more and more separated from each other—the upper rising tent-like about the outer ends of the spicular columns, the lower descending in a similar but inverted tent-like curve down the continuations of the columns beneath the skin, and so rounding off the upper corners of the intermarginal cavities. In correspondence with this thickening-out of the dermal mesoderm, its fusiform fibres diverge fan-like as they enter the spicular column, the more superficial ones running parallel to their respective surfaces. The fusiform fibres in the vicinity of the spicules run parallel to them, though near

the external ends of the spicular columns they appear to run at right angles to them, and appear to unite with them by their frayed and expanded ends.

At its base the spicular column expands by a thickening of the mesoderm as it extends along with the ectoderm over the upper face of the fibrous layer of the cortex, to form the floor of the subdermal cavities. Below this superficial stratum the fibrous layer consists of similar fusiform fibres to those of other parts of the mesoderm, but surrounded by a more condensed layer of matrix; they are about $\frac{1}{160}$ inch long, $\frac{1}{10000}$ inch wide, highly refractive, faintly bluish, granular, with an oval vesicular nucleus and round refractive nucleolus; the surrounding mesoderm, the walls of these cells, is clear, colourless, and sometimes slightly fibrillated. The inner face of the fibrous layer is coated with an adherent granular mark.

The fibrous layer is traversed by the smaller fusiform acerate spicules represented by Bowerbank (Brit. Spong. vol. i. fig. 362), which run through the fibres like stakes through wattlework. In Bowerbank's figure these spicules all lie parallel to each other, at right angles to the general direction of the fibrous layer; but in none of my slices is such an arrangement to be seen; the majority of the spicules run obliquely through the fibrous layer, sloping convergently towards the spicular columns at their base, and midway between crossing each other obliquely in different directions, some running at right angles to the fibres. The fibres of the fibrous layer lie concentric with the surface of the sponge, running in winding curves orientated in all directions, like the similar fibres in the cortex of *Stelletta Normani* (Ann. & Mag. Nat. Hist. 1880, vol. v. pl. vi. fig. 3). The deeper half of the fibrous layer has a duskier, darker tint than the more superficial, and takes a deeper stain with carmine. As to its function, it is probably a fibrous connective tissue, as I previously asserted of the corresponding layer of *Geodia Barretti* (Ann. & Mag. Nat. Hist. vol. v. p. 253).

The fibrous layer becomes still more modified in the same direction immediately about the ineurrent canals, a little below the middle of their course through it; here the fusiform axial threads are more closely approximated, the intervening tissue is of a darker grey, and the stain with carmine strikingly marked; the arrangement of the fibres is for the most part very regularly concentric; but a few are radiately disposed. With this change in appearance there is a change of function, and the fibres form a true muscular sphincter, which is to be observed in the prepared slices in all stages of

contraction. It is clear from the preponderance of the concentric fibres that the chief work done is in the contraction and closure of the sphincter; its return, on the relaxation of the concentric fibres, to a completely open state is completed by the opposing radiate fibres. This sphincter (Pl. VII. fig. 6) is precisely homologous with the chonal sphincters of *Geodina* and *Stelletina*. The fibrous layer with its spicules is homologous with the fibrous globate layer of the *Geodina*.

The Mark.—The mesoderm of the mark chiefly consists of a clear transparent matrix densely charged with more refractive, transparent, minute round granules ($\frac{1}{40000}$ to $\frac{1}{50000}$ inch in diameter), so thickly strewn that they appear almost in contact, and so evenly that no place seems to contain more than another: here and there at intervals small nuclei appear; and the mark surrounding them takes a deeper stain with carmine than elsewhere. If such a tissue as syncytium exists anywhere, then surely it is here. Fusiform fibres occur in the vicinity of the spicule-fibres, running parallel to the spicules, and also about the large water-canals, building around their course an indefinite fibrous layer. Most noteworthy are certain large granular amœbi-form cells with characteristically large oval nuclei and round nucleoli, like amœbiform ova, which are found embracing the spicules (Pl. VI. fig. 17) as though they were wandering cells creeping along them.

The endodermic cells of the flagellated chambers contribute a large share to the substance of the mark; they now appear as spherical vesicles $\frac{1}{3000}$ inch in diameter, containing a spherical nucleus $\frac{1}{10000}$ inch in diameter, which colours intensely with carmine. Carter has represented one of these chambers in his description of *Tetilla* (Ann. & Mag. Nat. Hist. 1872, vol. ix. pl. xxii. fig. 7), but has mistaken it for an ovum.

The Ova.—Sparsely scattered without apparent order through the mark are a number of very variously-shaped *Amœba*-like cells, distinguished by their disproportionately large nucleus and nucleolus. They occur of all sizes, from $\frac{1}{1200}$ inch diameter to $\frac{1}{180}$ inch, and are without doubt the ova in various stages of development. As soon as they attain a size of about $\frac{1}{700}$ inch across they occupy a distinct cavity in the mark, which serves as a brood-chamber. Pseudopodial extensions, which may become branched, proceed from them, and, passing out of the brood-chamber, wander for a considerable distance on the surrounding substance of the mark. No trace of fibrillation could be detected in these processes. The large oval nucleus, sometimes $\frac{1}{630}$ inch in diameter, with

its nucleolus $\frac{1}{2500}$ inch in diameter, looking like a globular oil-drop, lies nearer one end of the ovum than the other, imbedded in granular protoplasm, which immediately about the nucleus takes a far deeper stain with carmine than elsewhere. At the end of the cell, away from the nucleus, yolk-granules (for such I take to be the heap of large refractive granules represented at *g*, fig. 5) make their appearance, and increase in quantity with age till the whole cell is crowded with them, except in the immediate vicinity of the nucleus. Some of the yolk-granules appear to present a vesicular form. On the whole, one cannot help being impressed with the similarity of this ovum to that of *Hydra*.

The Spermatozoa.—In the three specimens I have examined no trace of these structures was discoverable; and since the ova occur in every stage of development, the presumption is in favour of the sexes being distinct in *Tetilla*. Large clusters of granules occupy a large part of some specimens; but these are segmentation-spheres of a developing parasite.

The Canal-system.—The characters and arrangement of the pores have already been described. They lead directly into the subdermal cavities, which extend continuously from one spicular column to another, and communicate between the columns with each other. In the floor of each subdermal cavity are the inner ends of several ectochones, separated by the usual sphincter from the corresponding endochones; it is thus clear that each subdermal cavity is equivalent to the outer halves of several ectochones which have become confluent, or, *vice versâ*, that those ectochones of a Geodine which lie in an area bounded by surrounding spicular fibres are equivalent to a single subdermal cavity of *Tetilla*. In *Stelletta Normani* this is neatly indicated by the subcortical crypts, which have just the same distribution below the fibrous cortex that the subdermal cavities of *Tetilla* have above it; they therefore clearly map out the areas which would be occupied by similar subdermal cavities were they present; and it is interesting therefore to find that they receive from the cortex not one but several endochones between each pair of spicular fibres, as shown in transverse section. The incurrent canals, after entering the mark, soon branch, and continue to branch repeatedly; but they give off at once and all along their course minute short canaliculi, which directly enter the flagellated chambers. These are $\frac{1}{1000}$ inch in diameter, nearly spherical, and very numerous developed. The chambers less abruptly communicate with the incurrent system by excurrent canaliculi, which are usually longer than the incurrent, the excurrent canals join together into a main

trunk, which traverses the cortex in a manner not yet observed, and then continues over its surface beneath a tunnel-like extension of the skin in the manner previously described, finally terminating in the osculum.

The Skeleton.—The main spicules, which are collected into fibres, are developed in granular spicule-cells, as will be more fully described in treating of the embryo. The cortical acerates and the fibrous layer are clearly homologous with the globate and fibrous layer of *Geodina*; and the inference is also deducible that the cortical acerates are likewise homologous with the geodine globates; surprising as this inference is at first sight, it is partly supported by the fact that both are developed in remarkably similar nucleated cells. Again, as the trichite sheaf is homologous with the globate, so it is also homologous with the *Tetilla* acerate; and here we are brought to see the essential difference between the sheaf and the acerate, the former being a fibrillated rod and the latter a concentrically-layered one.

The hamate spicules are found embracing a small round nucleus with a little granular sarcode; but no cell-wall is ever seen (Pl. VII. figs. 4 and 10); so that one is led to conjecture that the spicule may be the cell-wall, especially as it closely resembles in size and appearance the annular cell-wall, to which we have made frequent reference in describing the dermis. The nucleus of the hamate spicules is entirely different in size and character from that of the large spicule-cells and of the geodine globate; it is much smaller, no larger than the nucleolus of the latter, and shows no distinct nucleolus. It is of importance to notice that the hamates are not developed several in one cell, as Carter has asserted of the common tricurvedate spicules, as Schmidt has shown for the trichites of *Esperia*, and I, subsequently, for the trichites of *Stelletta Normani*; each hamate has sole possession of its own nucleus; in other words, each hamate cell produces but one hamate spicule. Carter mentions that he has also found two examples of a bihamate occurring singly in its mother cell (A. & M. N. H. 1874, vol. xiv. p. 104, pl. x. fig. 11).

The Embryo.—The segmentation of the ovum has not been observed in any of its stages; but sections of three embryos are shown in very thin slices; they each lie in a brood-chamber lined by a distinct membrane (endothelial) and a thin layer of fibrous tissue. Two, nearly spherical and 0.033 inch in diameter, are still solid throughout; the third (Pl. VII. fig. 1), oval, measuring 0.043 inch along its major and 0.033 inch along its minor axis, is also solid, except for the presence of the subdermal cavities, which are well developed over one

half the circumference, and the flagellated chambers, which are abundantly present in the mark and sometimes seem to be in connexion with the subdermal cavity by a minute incurrent canaliculus. There are otherwise no discernible canals in the mark. The mark is clearly distinguished from the cortical layer of gelatinous connective tissue which represents the non-fibrous layer of the adult cortex. The fibrous layer is at present represented merely by a thin layer of fusiform fibres in a granular gelatinous matrix, developed from the exterior of the mark and appertaining more to it than to the cortical gelatinous tissue; it is entirely unprovided with special spicules. The thick spiculated fibrous layer of the adult cortex is thus comparatively late in developing. No pores are yet visible in the skin, which consists of an external wrinkled membrane, with round nuclei in a layer beneath it (cuticula and ectoderm?), and a mesodermic layer of gelatinous connective tissue, containing pale oval granular cells dispersed through it. The subdermal cavities are lined by a thin membrane with round nuclei imbedded in it with tolerable regularity: this epithelium may be in continuation with the ectoderm somewhere; but my specimen does not show it. The centre of the mark consists of colourless gelatinous tissue containing irregularly stellate and fusiform cells; but its outer half is granular, as in the adult sponge, and crowded with flagellated chambers; if these are in connexion with a cleavage-cavity, it is curious that there is nothing in my specimen to indicate it. Many *Amæba*-like cells are present in the mark; and in one of them a young acerate spicule is seen almost wholly immersed, as though the latter had developed within it (Pl. VII. fig. 12); and, considering that the cell is almost precisely similar in shape and in the size and character of its nucleus and nucleolus to that in which the *Geodia* globate develops, this suggestion seems not improbable. With regard to the character of its nucleus it also resembles closely the ova of the sponge, but differs in other respects, its outer sarcode being more transparent, less densely finely granular, and staining much more faintly with carmine. Much more close is its resemblance to the *Amæba*-like cells previously mentioned as associated with some of the large spicules of the adult sponge: and on reexamining these I find that the association is much more common than I had before supposed; it appears in all not fully-developed spicules of which I could get a good view, and not only in *Tetilla*, but in *Geodia Barretti* and *Isops Phlegraei* as well; moreover, in a great number of cases I could trace from the heap of sarcode which surrounds the nucleus a thin granular film extending towards

each end of the spicule, up to which, indeed, it completely reaches (Pl. VII. fig. 18). In these cases the spicule-sheath is no other than a single enveloping large cell; and since the spicule increases in thickness by successive onlayerings to its surface, and nothing intervenes between it and the surrounding cell, we are obliged, so it would appear, to regard the latter as the medium through which the spicule increases in size; but the very young spicules appear in a similar cell, which only differs in being smaller and having a correspondingly smaller nucleus and nucleolus, *i. e.* in being younger. Hence it follows that the ensheathing cell is the true parent and nurse of the large spicules with which it is associated; it probably only disappears on the completion of their growth.

The spicules most conspicuously present are the projecting forks, which, with the grapnels with recurved rays and the long fusiform acerates, lie in parallel bundles, radiating not directly at right angles to the surface, but a little obliquely, their inner ends being tangential to an imaginary sphere concentric with the centre of the sponge. The tendency to a spiral arrangement, which Schmidt has well explained as naturally following from the form of the spicules, is thus early declared. Although the points of the forks frequently project through the skin, yet their centre of origin from the shaft always remains beneath or inside it. Most of the fully-developed grapnels (and most of them are fully developed, all three rays being present, although O. Schmidt asserts they do not become complete till the young sponge has left the parent) are completely covered by the skin; but those still incomplete, with only one or two teeth, as figured by Schmidt and Carter, more often protrude for some distance outside it, so that they appear to be in a retarded stage of development in adaptation to some special requirements of the larval state—it may be, for escape from the maternal tissues.

There are no short fusiform acerates, such as occur in the fibrous cortex of the adult; but hamates in their various forms are well represented.

Distribution. Kors Fiord, Norway, Station 13, 200–300 fathoms; Station 16, Station 23, 180 fathoms.

The species is also found about the Shetland Islands in deep water; Iceland, Florida: 152–183 fathoms.

The other described species of the genus are:—

1. *T. antarctica*, Carter, A. & M. N. H. 1872, vol. ix. p. 412, pl. xx. *Loc.* Antarctic Ocean, lat. $74\frac{1}{2}^{\circ}$ to $77\frac{1}{2}^{\circ}$ S., long. 175° W.; depth 206–300 fms. Distinguished by absence of hamates.

2. *T. arabica*, Carter, A. & M. N. H. 1869, vol. iv. p. 3, p. i. figs. 1 to 13, pl. ii. figs. 19 and 20. *Loc.* S.E. Arabia.

3. *T. atropurpureoidea*, Carter, A. & M. N. H. 1870, vol. vi. p. 176, pl. xiii. figs. 1-10. *Loc.* Unknown. Distinguished by its large hamates, which are spined, three terminal spines at each end giving them a resemblance to a tridentate anchorate.

4. *T. casula*, Carter, A. & M. N. H. 1871, vol. viii. p. 99, pl. iv. figs. 1-9. *Loc.* Port Elizabeth, Natal, Cape of Good Hope. Distinguished by absence of grapnel-like anchors and general form.

5. *T. dactyloidea*, Carter, A. & M. N. H. 1869, vol. iii. p. 15; 1872, vol. ix. p. 82, pl. x. figs. 1-5. *Loc.* S.E. coast of Arabia.

6. *T. euplocamus*, O. S. Spong. Alger. 1868, p. 40, pl. v. fig. 10. Desterro, Brazil.

7. *T. insidiosa*, O. S. Atl. Spong. Faun. 1870, p. 66, pl. vi. fig. 11. *Loc.* Florida, 17 fms.

8. *T. lens*, O. S. Atl. Spong. Faun. 1870, p. 66, pl. vi. fig. 10. *Loc.* Florida, 135-152 fms.

9. *T. polyura*, O. S. Atl. Spong. Faun. 1870, p. 66, pl. vi. fig. 8. Iceland, 85 fms.

10. *T. radiata*, Sclenka, Zeit. f. wiss. Zool. 1880, xxxiii. p. 467, pl. xxvii. *Loc.* Bay of Rio Janeiro, 3 fms.

11. *T. simillima*, Bwk. Proc. Zool. Soc. 1873, p. 15, pl. iii. figs. 6-13. *Loc.* South Seas.

12. *T. tethyoides*, O. S. Atl. Spong. Faun. 1870, p. 66, pl. vi. fig. 9. *Loc.* Florida, 100-123 fms.; Iceland.

13. *T. zetlandica*, Carter, A. & M. N. H. 1872, vol. ix. p. 417, pl. xxii. figs. 1-6, 11-17. *Loc.* Shetland Isles. Distinguished from *T. cranium* by the absence of hamates.

Schmidt's genus *Craniella* is defined as a corticate *Tetilla*, a rind according to Schmidt being absent in the latter genus; but since we have shown its decided presence in *T. cranium*, it becomes highly doubtful whether it is really absent in the remaining species; I have therefore reunited *Craniella* with *Tetilla* under the common name of *Tetilla*.

The absence of hamates from some species of *Tetilla* is probably a case of degeneration similar to that of the loss of trifold spicules in the geodine sponge *Caminus*, or of anchorates from Schmidt's species *Dirrhopalum clopetarium*, with regard to which Mr. S. O. Ridley*, in his exhaustive paper on his genus *Dirrhopalum*, confirms Schmidt's statement as to their absence, though not in the case of *D. gymnazon*, where

* "On the Genus *Plocamia*, Schmidt," by Stuart O. Ridley, Journ. Linn. Soc. vol. xv. p. 476.

he shows that they exist. Vosmaer*, falling into the old snare of classifying from a single character, exclaimed against my placing *D. plenum* along with Schmidt's forms, on the ground that it possesses anchorates, which the latter were not supposed to possess by Schmidt. I have no doubt that, on second thoughts, this able investigator will admit that the assemblage of characters is after all of greater importance than a single one.

Classification.—*Tetilla* is a genuine though somewhat divergent member of the corticate Choristidæ, with close affinities to the Desmacidina; it links together the suborders Tetractinellida and Monaxinellida. The evidence for this statement is found first in its embryological development, next in the characters of the Esperiad *Rhaphidotheca Marshall-Halli*, Kent. In the embryo we find some of its tetractinellid spicules in course of development; they commence with a swelling at the distal end of large uniaxial spicules, from which afterwards teeth are budded off one by one. This is true both for the grapnel- and fork-shaped spicules. Thus the uniaxial clearly precedes the tetractinellid form in development, a fact of signal importance in the discussion as to which originated first, Monaxinellida or Tetractinellida, and in complete correspondence with observations made on the order of development of the spicules in the Calcispongia.

In the next place, in *Rhaphidotheca Marshall-Halli* we find the distal ends of some of the large spicules which project from the skeletal fibres beyond the skin distinctly thickened into globular or oval or cylindrical bulbs, in which the axial thread ends in a slight spherical expansion. To suppose that these spicules are parasitic in nature or foreign bodies appropriated by the sponge is an altogether untenable idea, as I shall show when dealing more in detail with this species; they agree in all respects with the other chief spicules of the sponge, except in this one important particular, that they have a dilated or thickened distal end, and thus maintain persistently, though in an exaggerated form, a stage through which the trifold spicules of *Tetilla* very rapidly pass. The rounded swelling of the distal ends of projecting spicules is not confined to *Rhaphidotheca*; I have it in a less marked form in a suberite to which I give the name of *Radiella schænus* (σχοῖνος, a bull-rush).

In the next place, amongst the various forms of small spicules with which *Rhaphidotheca* is richly provided, we find trichite sheaves and C- and S-shaped hamates. The pre-

* 'The Sponges of the Leyden Museum,' by G. C. J. Vosmaer. Family Desmacidinae, p. 154.

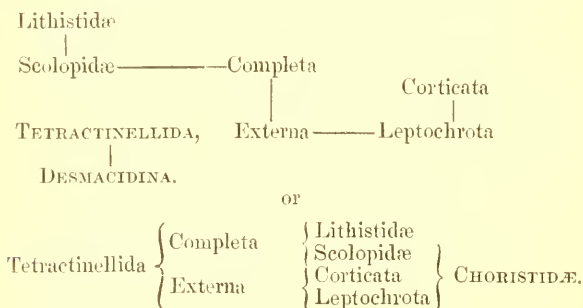
sence of the latter, so characteristic throughout the Desmacidina, would of itself have afforded us a hint as to the alliances of *Tetilla*; but, taken in conjunction with the evidence furnished by the ends of the spicules, it gives us a very strong case indeed. The swollen terminations of the spicules of *R. schævus* suggest the possibility of a polyphyletic origin for the Tetractinellida. The trichite sheaves of *Rhaphidotheca* deserve a word of mention; for though they are found in several groups of sponges, yet they are most commonly present in Desmacidina and *Stelletta*; and a genetic connexion between these two groups being probable on other grounds, we may regard the sheaves as derived from a common ancestor, and thus gain some hope of tracing out their origin in the other group of sponges in which they occur.

If the *Tetilla* embryo, taken in conjunction with *Rhaphidotheca*, furnishes evidence of a passage from the Monaxinellida to the Tetractinellida, so no less does it show by the late development of its rind a passage from the non-corticate to the corticate sponges, and proves, what we should have predicted on *à priori* grounds, that the latter were preceded by the former. Schmidt's group of Corticata (Rindenschwämme), though heterogeneous as at first constituted, appears to me a good one if restricted to Tetractinellid sponges possessing rinds; and I consequently adopt it so amended in the table which follows below. This appears to be a good place for offering a few observations on the classification of the Tetractinellida. In my paper on the Trimmingham flints I proposed to divide the Tetractinellida into those with loose or separate spicules (Choristidæ) and those with spicules mutually interlocked to form a network (Lithistidæ). Zittel, placing greater stress on the branching character of the latter spicules, had previously declared for a wider separation between the Choristidæ (Tetractinellida) and Lithistids than this would imply; but Oscar Schmidt (rightly, as it seems to me) declares this four-rayed character of the spicules to be fundamental, although he maintains the ordinal distinction of Tetractinellida (my Choristidæ) and the Lithistidæ. The presence in the Lithistidæ of trifid forks and anchors precisely similar to those of the Choristidæ is for me a strong point in favour of their common derivation; and the primary difference lies in the different character of the chief four-rayed elements. In the Choristidæ the chief tetractinellid spicules are confined to the surface (the tetractinellid character is only skin deep); and they are clearly differentiated into shaft and rays, which have a very definite direction with regard to the surface of the sponge, the shaft being usually radial and the rays developed

at its distal end. In the Lithistidæ the distinction into shaft and rays is not strictly maintained, but all four rays have the same value, and start at once from a common centre; moreover they are the chief skeletal spicules, while in many of the Choristidæ the mass of the chief spicules are uniaxial.

Thus, as the Tetractinellid character is the most fundamental, I propose to include all sponges which exhibit it as Tetractinellida; and as the next differentiation would appear to result from the development of quadriaxial body-spicules in Tetractinellids which previously possessed only trifid superficial spicules, I divide the Tetractinellida into Tetractinellida Externa and Completa. The Externa will then fall into Corticata and Non-corticata (Leptochrota, thin-skinned), the Completa into Scolopidæ (sharp-pointed), such as *Dercitus*, and Lithistidæ. The term Choristid may still be conveniently used to designate Tetractinellids in which the spicules are not conjoined into a lithistid network.

The following Table shows the relations between the different Tetractinellida as I conceive them to exist:—



EXPLANATION OF THE PLATES.

PLATE VI.

Pachymatisma Johnstoni.

- Fig. 1.* Section through the oscular tube (T), separated by the sphincter from the underlying oscular chamber (C): *b*, bacillar layer; *v*, vacuolated connective tissue; *c*, gelatinous connective tissue; *f*, fibrous layer. $\times 11$.
- Fig. 2.* Section through the sponge, showing the oscular tube (*a*) and the oscular chamber (*b*), with main excurrent canals (*c*) opening into it. Nat. size.
- Fig. 3.* Section through the commencement of an incurrent tube, showing the poral canals, ectochone, and sphincter. $\times 15$.
- Fig. 4.* View from above of the poriferous roof: *a*, chone; *p*, pore; *g*, globose spicule. $\times 23$.

- Fig. 5.* Vacuolated or vesicular connective tissue, with the gelatinous matrix becoming fibrillated. $\times 315$.
Fig. 6. Quadrifid proximal end of a trifid fork.
Fig. 7. A twinned spicule.
Fig. 8. Distal end of a spicule with fork and grapnel-ray.
Fig. 9. Tubercular outgrowths on distal ends of spicules.
Fig. 10. Bacilli: *a-c*, in successive stages of development; *a*, earliest stage; *b*, second stage; *c*, adult spicule; *d* and *e*, varieties with an additional ray.
Fig. 11. Connecting fibres between two globates, showing imbedded granular threads with nuclei. $\times 640$.
Fig. 12. Cells with granules of reserve food. $\times 315$.
Fig. 13. Vacuolated or vesicular tissue at the edge of an ectochone: *g*, globate spicules. $\times 157$.

PLATE VII.

Tetilla cranium.

- Fig. 1.* Section through an embryo still imbedded in the maternal tissues ($\times 26$).
Fig. 2. Section of the upper corner of a subdermal cavity ($\times 157$).
Fig. 3. Section through the entire sponge (nat. size).
Fig. 4. Hamate spicules enclosing nuclei ($\times 640$).
Fig. 5. Ovum with extended pseudopodium-like processes: *g*, yolk-granules. $\times 157$.
Fig. 6. Section through a part of the sponge, showing the structure of the cortex, subdermal cavities, and the oscular tube (*o*) cut across ($\times 15$).
Fig. 7. Poriferous membrane of fig. 15 ($\times 157$). The crossing lines, indicating fibrils, have been too heavily drawn by the engraver.
Fig. 8. Network forming the floor of the oscular tube ($\times 157$).
Fig. 9. A node of the preceding network ($\times 500$).
Fig. 10. A trabecula of the same ($\times 640$).
Fig. 11. Axial thread of one of the fibres of the fibrous connective tissue ($\times 640$).
Fig. 12. Young spicule in its cell from a *Tetilla* embryo ($\times 640$).
Fig. 13. Ectoderm from the interior of a subdermal cavity ($\times 640$).
Fig. 14. Endodermic cells from the walls of a flagellated chamber ($\times 640$).
Fig. 15. External view of the skin, showing pores in poriferous areas ($\times 52$).
Fig. 16. External view of the skin, with its fibrous network showing through; the meshes of the network are not subdivided as in preceding figure, but pores are still present. $\times 23$.
Fig. 17. Spicule-cell surrounding a large chief spicule, drawn on same scale as fig. 12, to show the increase in size of the nucleus and nucleolus ($\times 640$).
Fig. 18. Large spicule completely enclosed in spicule-cell ($\times 166$).

[To be continued.]